Strategy Research Project

SPACE AND AIRBORNE COMMUNICATIONS FOR THE FUTURE FORCE

BY

MR. TOMÁS A. PAGÁN
Department of Army Civilian

USAWC CLASS OF 2010

Prudens Futuri

U.S. Army War College, Carlisle Barracks, PA 17013-5050

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
23-03-2010

2. REPORT TYPE
Strategy Research Project

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Space and Airborne Communications for the Future Force

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Me. Tomás A. Pagán

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Professor David J. Smith
Center for Strategic Leadership

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army War College
122 Forbes Avenue
Carlisle, PA 17013

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution A: Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This paper will discuss options for providing wide area communications support to the force of the future. The topic at hand – first, is to provide some context for "vertical communications support" and second, to show some (but not all) of is the more interesting options. The message is that there is a need now for more communications over a wider area than we have seen before; that need is going to grow in both dimensions; but there are new opportunities to support those communications that need further investigation. There are exciting new opportunities to be considered associated with newer technology – but with corresponding technical, operational and economic challenges. Additional research and development of a variety of options as well as close coordination between the military and industry communities is essential to meet warfighters requirements for the future force.

15. SUBJECT TERMS
Vertical Communications Support

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFED	UNCLASSIFED	UNCLASSIFED	UNLIMITED	28	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

USAWC STRATEGY RESEARCH PROJECT

SPACE AND AIRBORNE COMMUNICATIONS FOR THE FUTURE FORCE

by

Mr. Tomás A. Pagán
Department of Army Civilian

Professor David J. Smith
Project Adviser

This SRP is submitted in partial fulfillment of the requirements of the Master of Strategic Studies Degree. The U.S. Army War College is accredited by the Commission on Higher Education of the Middle States Association of Colleges and Schools, 3624 Market Street, Philadelphia, PA 19104, (215) 662-5606. The Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

ABSTRACT

AUTHOR: Mr. Tomás A. Pagán

TITLE: Space and Airborne Communications for the Future Force

FORMAT: Strategy Research Project

DATE: 23 March 2010 WORD COUNT: 5,063 PAGES: 28

KEY TERMS: Vertical Communications Support

CLASSIFICATION: Unclassified

This paper will discuss options for providing wide area communications support to the force of the future. The topic at hand – first, is to provide some context for “vertical communications support” and second, to show some (but not all) of is the more interesting options. The message is that there is a need now for more communications over a wider area than we have seen before; that need is going to grow in both dimensions; but there are new opportunities to support those communications that need further investigation. There are exciting new opportunities to be considered associated with newer technology – but with corresponding technical, operational and economic challenges. Additional research and development of a variety of options as well as close coordination between the military and industry communities is essential to meet warfighters requirements for the future force.

SPACE AND AIRBORNE COMMUNICATIONS FOR THE FUTURE FORCE

> In the years ahead, the United States will confront complex, dynamic and unanticipated challenges to our national security and to the collective security of our friends and allies. These challenges will occur in many forms and will be waged across the spectrum of conflict- ranging from peaceful competition to general war and at points in between. [1]
>
> —General George W. Casey, Jr.

To achieve Information superiority, Joint Force Commanders must have the right information at the right place at the right time in order to make the best decisions to advance and protect U.S. National Security interests. An essential enabler towards that end is sufficient wideband communications connectivity. Current Department of Defense (DoD) wideband communications capabilities are insufficient. The challenge is to dedicate sufficient resources in the most efficient manner to meet this growing need in the face of severe time pressure. The reality is that the current operational environment demonstrates the lack of an integrated architecture that provides robust communications to the lowest war fighting echelons under the most adverse conditions. The current fight and future threat require the network transport to evolve to a multi layered solution (terrestrial –air-space). Greater connectivity will expand situational awareness and facilitate communications among all types of modular brigades enabling them to enjoy greater mobility, especially if communications can be maintained while on the move and in austere environments. Such capability will also improve the range of support for non organic fires and intelligence.

This paper will discuss options for providing wide area communications support to the future force. The topic at hand is first, to provide some context for “vertical communications support” and second, to show some (but not all) of the options with greatest potential. The message is that there is a need now for more communications over a wider area than we have seen before; that need is going to grow in both dimensions; but there are new opportunities to support those communications requirement that need further investigation. In cases where the required capability does not currently exist, the “capability gap” must be fed into the requirements and acquisition process.

Historical Context

Operation DESERT STORM is often considered the First Space War. The term *“First Space War” h*as many implications – but for the Army it refers to the application of space assets down to the tactical and operational levels. The effectiveness of the Global Positioning System (GPS), even in a single channel unit without access to the military Precision “P” code, was widely recognized by the Army resulting in GPS becoming the de facto standard. Before DESERT STORM it was not at all clear this would be true. The Army had been aggressively working the issue of providing products from National Intelligence Assets directly to the warfighter through Tactical Exploitation of National Capabilities Program (TENCAP). DESERT STORM provided the opportunity to demonstrate the value of these products and another hotly debated issue was settled. Satellite Communications (SATCOM) usage was significant for the time and it was not all military. Much of the TENCAP dissemination was done through the Trojan Spirit Special Purpose Integrated Remote Intelligence Terminal [2] – a leased, commercial C-band system. But the rise in communications requirements had just begun. A mere 8 years later satellite communications usage had increased by a factor of 2.5. NOBLE ANVIL was the US component to NATO Operation Allied Force in 1999 dealing with Yugoslavia and Kosovo. [3] As shown in Figure 1, recent Space Load

Communications, the demand for SATCOM by deployed military has grown markedly since Operation DESERT STORM in 1991.

- OEF/OIF Peak Operations (May 03) - 3200 Mbps
- OEF/OIF (Jan 04) - 2730 Mbps
- ~80% is Commercial Today
- Military Satellite Communication (MILSATCOM) capacity about 15-20% of OIF Peak Demand

Figure 1: Recent Space Communications Load

Figure 1 adds two points to the growth curve based on recent experience. Over an order of magnitude increase in just four years – and it has not dropped substantially even with the change from major combat operations to stability and recovery operations.

Two measures of military capacity are shown here. The first is a statement by GEN Kevin Chilton, then Commander, Air Force Space Command, describing the situation in 2004. One source places the wideband MILSATCOM capability in the early 2000s at 530Mbps.[4] The second indicates that the limitation is not just a matter of choice. Estimate in 2010 is that eighty percent is commercially provided.[5] That percentage is expected to climb north of 90 percent in the near future as unmanned aerial vehicles and other Intelligence, Surveillance and Reconnaissance (ISR) systems begin transmitting in high definition, which will require even more capacity.[6] Even though MILSATCOM capacity will grow substantially as the program is executed – a single Wideband Global System (WGS) satellite will provide more bandwidth than the entire Defense Satellite Communications System (DSCS) constellation – there are still large gaps predicted for future conflicts. Yet WGS is not the panacea for wideband bandwidth. But note that even with the increases shown here - shortfalls are predicted.

> The requirements shortfalls are determined based upon subtracting on-orbit capacity from requirements totals. As of March 2006, only 5 WGS were to be procured and the Wideband SATCOM shortfalls were predicted to exceed 15 Gbps in 2012 and grow to exceed 30 Gbps by 2018. These enormous shortfalls existed without any future procurement strategy to address them.[7]

Worth pointing that as of Oct 2009, this shortfall gained national attention to the extent that additional WGS are being acquired to address it. It is assumed that this will not be the full answer and therefore a new effort, called the Joint Space Communications Layer, started in late 2009, will perform studies to provide an Analysis of Alternatives (AOA) on how best to meet the growing SATCOM requirements.

Where does the growing requirement come from? In the cases shown here it is almost all “reachback” and has – in the opinion of the author and many others –not yet taken full account of the “intra-theater” traffic that may be required by network-centric operations.[8] One clear example of this is reconnaissance by Unmanned Aerial Vehicles (UAV) like Global Hawk (GH). GH and Predator both operating through satellite link back to home station. One estimate is that data exfiltration of airborne ISR will consume 25 to 40% of the wideband satellite requirement in 2012.[9] A single Global Hawk radar image is about 128 Mega Bytes as an example.

Current Situation

Commercial Satellite Communications
• More than 200 Commercial Satellites in Geostationary Orbit – Mixture of C, Ku, and Ka bands • Supply vs. Demand – In 2002 Capacity > Demand by 100,000 MHz – In 2009 Overcapacity is predicted to drop to between 30,000 and 40,000 MHz. • Cost – Spot market • $150,000 per month for one 36MHz Ku transponder • 10 Year Lease about 40% less

Table 1: Commercial Satellite Communications

Table 1 provides some insight into the current situation reference the availability of commercial satellite communications. One of the big concerns in past debates over the practicality of using commercial communications was the availability of that capacity in a hurry in the region of interest. The data here – drawn from projections by the Satellite Industry Association – indicate that now is as good a time as any to need additional commercial satellite bandwidth. However, the surplus is projected to tighten over the next few years. By way of comparison, it costs about $250M to put a large commercial communications satellite in Geosynchronous Earth Orbit.[10] The lease prices illustrate the ongoing debate concerning short term vs. long term lease. If you know you are going to need the additional capacity for the next decade, there is much to be gained from a long term lease. The spot market prices amount to just under $2M for a “transponder-year”. All things being equal it scales to about $54M per year per gigabit per second.

Operation Iraqi Freedom (OIF) saw extensive use of commercial satellites for in-theater traffic. Force XXI Battle Command Brigade and Below (FBCB2) became one of the real successes - commercial satellite-based support for Blue Force Tracking (BFT) (FBCB2) in addition to the Enhanced Position Location and Reporting System (EPLRS) based military system.

Joint Network Node (JNN) facilitates fixed site operations – down to Brigade and approaching Battalion[11]. JNN was fielded down to the Battalion level in Iraq. Deployment started in late 2004. Strictly commercial equipment, it is relocatable, but cannot operate on the move. JNN is, since renamed, a part of the Warfighter Information Network Tactical (WIN-T) Increment 2 efforts. It should be noted that WIN-T Increment 2 is cited to critical to the future of the Army’s Landwarnet, which is he service’s contribution to the Global information Grid (GIG).[12]

Figure 2[13] below shows both the existing military communications satellites and current plans for the future.

<u>Existing</u> - Military Strategic and Tactical Relay (MILSTAR); Defense Satellite Communication System (DSCS); UHF Follow-On (UFO)); Global Broadcast System (GBS)) is an ad-on package to the UFO satellites.

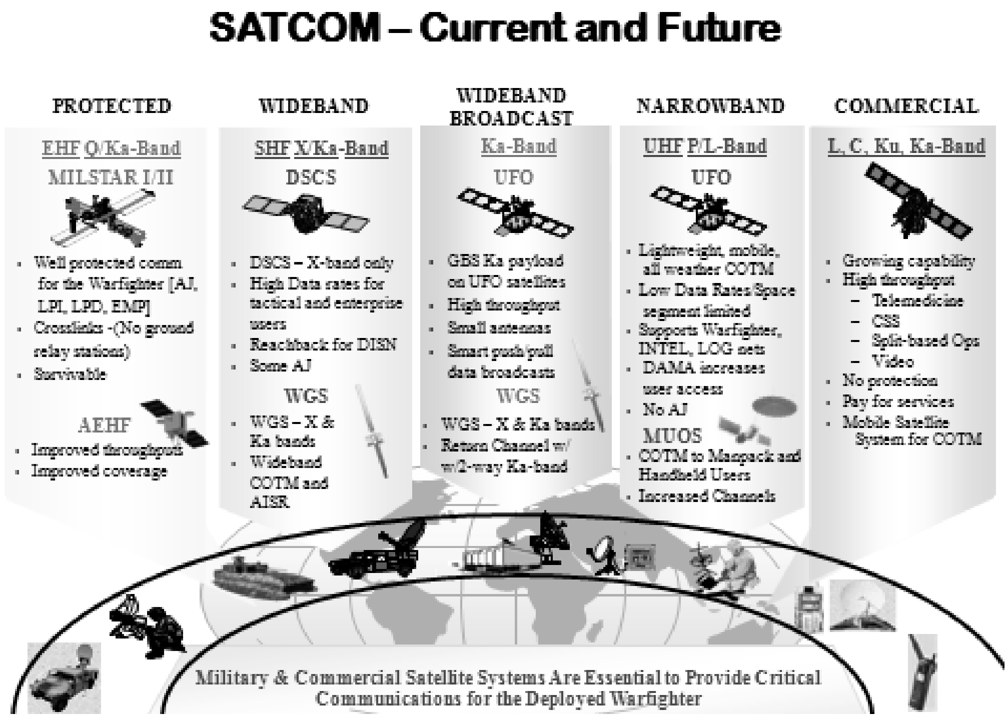

Figure 2: SATCOM Current and Future

Existing				
HF Q/Ka- Band **MILSTARI/II**	SHF X/Ka- Band **DSCS**	Ka-Band **UFO**	UHF PL-Band **UFO**	L, C, Ku, Ka-Band
• Well protected comm for the Warfighter [Anti Jaming (AJ), Low Probability of Intercept (LPI), Low Probability Detect (LPD), Electro Magnetic Pulse EMP] • Crosslinks -(No ground relay stations) • Survivable	• DSCS – X-band only • High Data rates for tactical and enterprise users • Reach back for Defense Information System Network (DISN) • Some AJ	• GBS Ka payload on UFO satellites • High throughput • Small antennas • Smart push/pull data broadcasts	• Lightweight, mobile, all weather Communication On the Move (COTM) • Low Data Rates/Space segment limited • Supports Warfighter, INTEL, LOG nets • Demand Assigned Multiple Access (DAMA) increases user access • No AJ	• Growing capability • High throughput – Telemedicine – CSS – Split-based Ops – Video • No protection • Pay for services • Mobile Satellite System for COTM

Figure 3: Existing SATCOM

Future – AEHF (Advanced Extremely High Frequency); and until recently and not represented here is (Transformational Satellite Communications System (TSAT)) to be discussed later; WGS (Wideband Gap filler System); MUOS (Mobile User Objective System).

Future			
PROTECTED	WIDEBAND	WIDEBAND AND BROADCAST	NARROWBAND
AEHF	**WGS**	**WGS**	**MUOS**
• Improved throughputs • Improved coverage	• WGS – X & Ka bands • Wideband COTM and AISR	• WGS – X & Ka bands • Return Channel w/w/2-way Ka-band	• COTM to Manpack and Handheld Users • Increased Channels

Figure 4: Future SATCOM

Most of the existing Military satellites deal with wideband data and have until recently required large antennas. Some antennas such as SMART-T (Secure, Mobile Anti-Jam, reliable, Tactical Terminal) are fairly small for quick set-up and tear down.[14] UFO and MUOS are for individuals or moving platforms. But they are low data rate and quickly saturate with number of users. All of these are in GEO. Although commercial communications satellites are shown as 20% of the chart – they actually outnumber the military communications satellites. This system will be discussed in greater detail later in this paper.

A key difference between the military and commercial satellites is in the degree of protection and anti-jam capability. Most, but not all, of the military satellites have some AJ capability. MILSTAR has significant capability; the TSAT as envisioned has significant requirements for Anti Jamming (AJ). On orbit, not much has changed for military SATCOM in the last decade.

Requirements for the Force of the Future

As the Current Force moves to the Force of the Future, there is increasing emphasis on network centric operations. How is this going to change the current view?

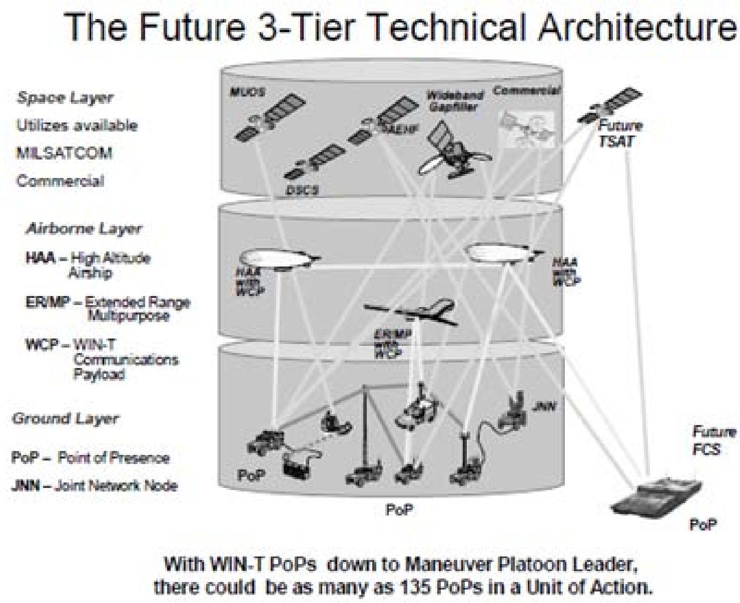

Figure 5: The Future 3 Tier Technical Architecture

This figure has been adapted from a set of charts from PM WIN-T (the Warfighter Information Network – Tactical). Just about every depiction of the future communications architecture presents a similar picture. In these three-layer architectures there is a netted ground force (the ground or terrestrial layer) tied to airborne and space layers through a series of PoPs – or points of presence. So there are “vertical shortcuts” within the force through both the airborne and space layers. Future capabilities are somewhat depicted in this chart as to the right – TSAT and FCS are outside the box – but are foreseen to have the same connectivity.

The space layer does not differ much from one proposed architecture to the next – everyone rounds up the usual cast of characters (or suspects as may be more appropriate). Space links are primarily reach back – out of the immediate AOR – but some "intra-AOR" links are included.

There is often significant variation in the platforms depicted in the airborne layer showing a lack of consensus and service priorities. The architecture in figure 5 depicts the High Altitude Airship and a UAV – the Extended Range /Multi Purpose (ER/MP) or Warrior. Another Army architecture might possibly depict the airborne layer composed of all UAVs – particularly class IV.[15] As a point of reference, the Army WIN-T program acknowledges the need for the airborne layer and is developing a WIN-T Communications Package that can be placed in these two types of UAS. There are the ER/MP and the Class IV UAS. The Communication Package that will go into the Class IV UAV will be deployed with the proposed Brigade Combat Team (BCT)'s. The Communications package that will go on the Extended Range Multi Purpose (ERMP) UAV will be designed for use with all other maneuver units. This means that the UAV's fielded to Army Units can be contemplated to be used in one of the three possible ways: As an ISR collection, an airborne communications node, or as a combination of both, thus providing a limiting capability to do both.

In many Air Force versions, the airborne layer is mostly large Air Force aircraft that are there anyway – Airborne Warning and Control System (AWACS), Joint Surveillance and target Attack Radar System (JSTARS), etc. The note at the bottom of Figure 5 is intended to illustrate how it is key to future operations regarding this "vertical hop". In earlier analyses of network centric operations with FCS like forces, there are as many as 135 PoPs in a brigade – or one for each platoon.

These numbers do not represent any official program of record decisions – just one possible future – albeit one with some analysis behind it. Compounding the issue are recent concerns about airspace management coming from recent experience in Iraq with large numbers of UAVs controlled by lower echelon ground forces.[16]

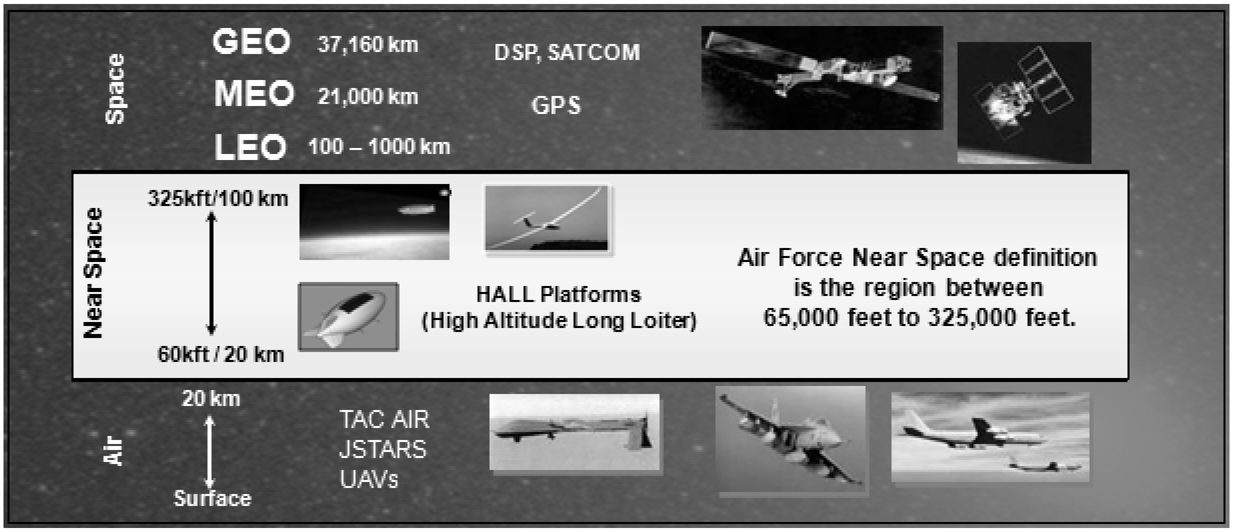

Figure 6: Space and Airborne Layers

Options for Space and Airborne Layers

Figure 6 depicts options for the space and airborne layers. Having addressed the importance of vertical pathways, these are some of the options for implementing them.[17]

The term "near space" has emerged over the last few years as an altitude regime that is currently underused, but with great potential for the future. Near space is the altitude band in which most aircraft stop flying and where satellite orbits decay quickly – shown here at about 20 to 100 km. This band is typically seen as having several advantages – 1. It is above the current air space management problem – 2. It is above most weather – 3. It has a large field of regard [the area with Line of Sight (LOS) to the platform] – usually seen as a definite advantage – and 4. There is a realistic possibility of long loiter - from days to a month to an indefinite period depending on each user's optimism. Making the trade-off between platforms at these altitude bands is not always easy – it is a multi-faceted milieu of operational, technical and economic issues.

Dr. Darrell W. Collier has performed some salient analysis that sheds light on some of the more interesting trades regarding altitude vs. persistence thus providing some fidelity and discussion of his analysis.

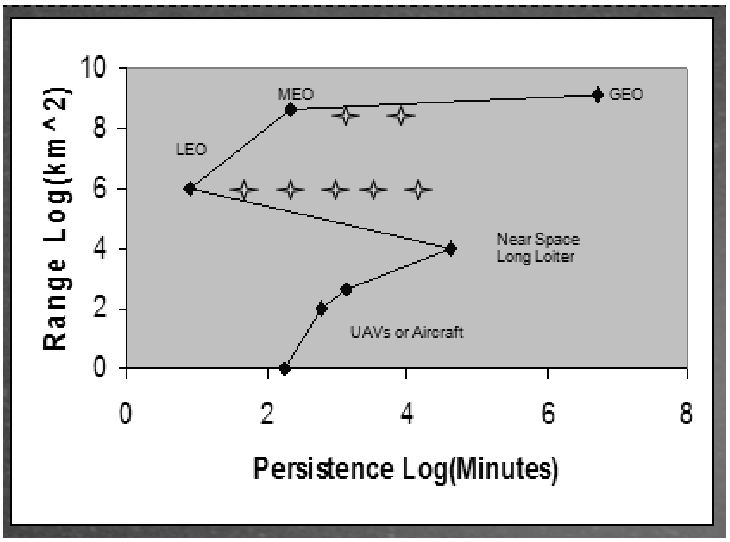

Figure 7: Altitude versus Persistence[18]

Taking a simple view of communications – range is important. Range is defined as an area in which something acts or operates or has power or control. So Range is shown here as range-squared since most physical phenomena (either signal strength or resolution) go as $1/R^2$. In fact it is range squared that counts. All kind of things get worse quickly as the distance over which one must transmit grows including antenna size, transmit power, waste heat, time delays, etc. The vertical axis on this chart is the log of R^2 – all things being equal, lower altitude is better.

Persistence is also a key characteristic. One can view persistence in the communication domain as meaning 24/7 connectivity for narrowband and broadband communications. In technical terms, Persistence is largely determined by the platform and is usually measured by time on station. The epitome of persistence is the geosynchronous satellite. Plotted on this chart are points that approximate range and persistence for the usual platforms.

Geostationary Earth Orbit (GEO) satellites can operate successfully for 10 to 15 years – but they are a long way from earth and require delicate balances of antenna size, transmit power and data rate for ground terminals. Typically four or five GEO satellites provide complete earth coverage. Medium Earth Orbit (MEO) satellites – such as GPS – are a lot closer but still a long way out there. The time shown here is an approximate value for a single MEO platform to provide coverage to a ground station above an elevation of about 20 degrees from the horizon. Because the orbit is no longer stationary in earth terms, one platform will not provide continuous coverage. A constellation is required as shown schematically here by the extra "Stars". GPS has 18 to 24 satellites in three orbital planes to provide a continuous view from four satellites at any point of the earth.

Range improves, but persistence gets worse when moving to LEO. Iridium Limited Liability Company (LLC) uses a constellation of 66 satellites. [19]
The UAV / aircraft points are approximations for several existing platforms. High altitude UAVs already offer the possibility of one to two days loiter – reducing the constellation size accordingly and providing a good mix of range and persistence.

The near space point adds an interesting twist to the curve – if indeed one month or more is possible at these altitudes, then it is an interesting option.

The drawback on persistence is that it can slow modernization. For example, because DSCS was developed so long ago – the capability is severely lacking when compared to modern communications satellites. DSCS has been outdated for more than two decades. Cost will be discussed as part of the varying options. Although cost is always a risky area, total cost – including ground terminal costs, is often elusive.

- Generally, Higher Altitude is better
  - Larger Field of Regard
  - Antenna Pattern Determines Field of View
- Larger area coverage
  - May be better, Low Volume Traffic
  - May be worst, High Volume Traffic

Table 2: Field of Regard

The Field Of Regard of the higher altitude platforms is quite large. Both GEO and MEO cover the whole hemisphere facing the satellite. The actual field of view for communications purposes is determined by the antenna. For GEO platforms there are often multiple antennas with different Field of Views (FOV)s – a low data rate “whole earth” beam and various higher data rate lower cross-section beams. For moving platforms, some complications may exist because of the need to keep the antenna focused on the platforms’ area of responsibility. The details of the antenna are very sensitive to the aerodynamic environment and the structure of the platform. For example, space vehicles can have very large and awkward antenna structures as long as they can be folded up for launch. Aerodynamic vehicles on the other hand need aerodynamic antennae – perhaps with a great deal of structural strength. The point here is that the trade-off is very dependent on application details. And bigger is not always better. The system must be able to deal with all signals in the FOR. Perhaps it can easily reject them because they are out of band – or receive them in their time slot. Antenna patterns can be constructed to narrow the field of view if appropriate – but all antennae have side lobes which are a consideration as well.

Perhaps it is best if the FOR just matches the field of interest – but experience has shown that nothing remains static for long.

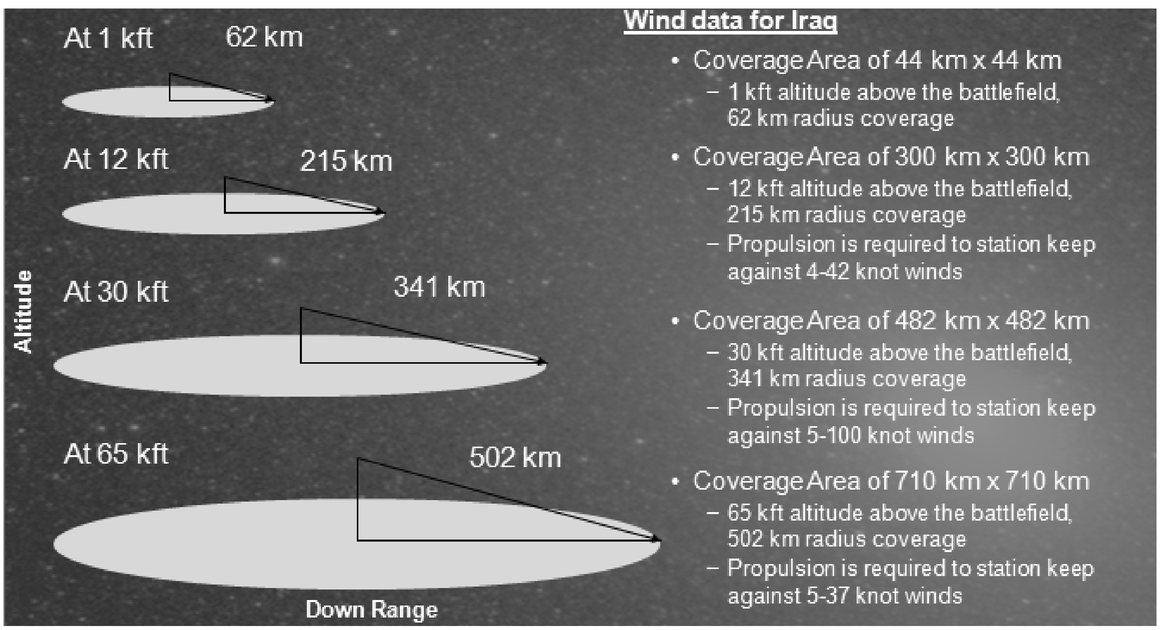

Figure 8: Altitude Sensitivity (Line of Sight to the Horizon)[20]

The Field Of Regard (FOR) – measured by the distance to the horizon – is quite large as the employment of capabilities approaches near space altitudes. Of course, at MEO and GEO altitudes, the entire hemisphere facing the satellite is within line of sight to the platform. A Low Earth Orbit (LEO) satellite at an altitude of 1,000km sees an arc of the earth surface at approximately 5,500km or a straight line (chord) of about 6,400km. At the middle altitudes (30kft or 10km), the FOR is large enough to support communications relay within a brigade-sized unit and relay between adjacent units. At near space altitudes, the FOR is large enough to support relay out of theater for all but the largest theaters as well as relay within and between units. As an example, the distance from Baghdad to Kuwait is about 500km. It should be noted that imposing a realistic elevation angle on a ground transmitter will decrease the Line Of Sight (LOS) ranges.

Future Candidates

The intent is not to discuss all possible options in each altitude regime, but rather point out some of the ones with the greatest potential to meet near term communication requirements.

Future Candidates for the Space Layer

Transformational Satellite Communications System (TSAT). TSAT is still the vision of where GEO communications needs to go. The requirements were derived with network centric operations in mind: it accommodates the disadvantaged user, and it provides very high capacity cross links for reach back. Like all space systems these days, TSAT was the subject of an acquisition debate where technical risk and cost growth concerns and associated schedule issues caused the program to significantly slip resulting in its cancellation by the Department of Defense.[21] The actual availability for important GEO capabilities such as assured communication on the move and "bandwidth to the edge" is somewhat uncertain. Although TSAT is likely to be outside the cost envelope of previous systems because of the requirements, experience has demonstrated that GEO communications satellites are on the order of $300M each.[22]

Tactical Satellite (TacSat). Another space based alternative is TacSat, a Low Earth Orbit (LEO) system designed to provide the warfighter with "Transformational" space-based capability, e.g., a low-cost, quick response launch capability for a range of available payloads; a system that is an integral part of the joint task force commander's operational plans. Termed Operational Responsive Space (ORS), this concept focuses on quickly providing joint military capabilities to satisfy the demands of operational and tactical-level commanders. Critical to achieving the agility and flexibility demanded by an ORS model are standards for modular/scalable satellite buses (backbone of the satellite) currently in development. Standardization and "modular interfaces" will decrease development costs, foster industry involvement and decrease the time required to build a satellite to meet an operational commander's needs. The key here is that one can configure a LEO constellation that is best suited to the AOR and type of operation at hand. If costs are low enough, the constellation could be considered expendable at the end of the operation. Knowing the AOR could greatly reduce the constellation size for persistence. If LEO costs of $25-50M per satellite could be attained for a constellation lasting a year then it becomes cost competitive with large UAVs (e.g., Global Hawk). It is not clear what the O&M costs are in each case, or how many of each it would take to meet operational but it is certainly worth exploring.

<u>Future Candidates for the Near Space Layer</u>

High Altitude Airship Program Demonstrator. The High Altitude Airship (HAA) Program was a Missile Defense Agency (MDA) led program with technical support from U.S. Army Space Missile Defense Command)/Army Forces Strategic Command (USASMDC/ARSTRAT), it's Technical Center SMDTC, and it's Space Division. Lockheed Martin, Akron, OH, was the prime contractor. Despite cancellation, the Army

SMDC continues with plans to ultimately develop a prototype HAA that will loiter at greater than 60,000 feet for duration of more than 30 days with a payload of 500 lbs. and payload power of 3kw. Towards this envisioned prototype development and flight, there is a parallel technology improvement phase, led by USASMDC/ARSTRAT, to develop new technology in fabric and power to be used for the follow-on development and flight of the objective system. The intent is to develop both a lighter and stronger fabric as well as a high power generative power system. The objective system is to fly at an altitude of 60,000 feet with a payload of 2,000 lbs. and a payload power of 15 kw for a duration of more than 30 days.[23]

Darpa ISIS Program. The "Integrated Sensor Is the System" (ISIS) is a lighter-than-air system designed to operate at 70,000 feet altitude and remain on station for more than 30 days for its prototype and one year for the objective system.[24] The prototype is a 1/3 scale model and is scheduled to be demonstrated in 2010. The radar payload will be integrated as part of the structure. In principle, the concept can be applied to communications technology by integrating the antenna structure into the envelope of the airship. This could provide the communications equivalent of a phased array antenna, or a very flexible antenna pattern with considerable anti-jam capability through antenna nulls.

Orion Vehicle Concept. At the lower edge of the near space altitude band, powered flight is possible (as shown by Global Hawk). Orion is a propeller-driven concept to provide increased endurance at lower cost. The platform is another heavier than air hydrogen powered unmanned aerial vehicle initiative managed by USA Space Missile Defense Command Technology Center (SMDTC). The objective of the system is to fly for four days on station and provide a payload capability over extended ranges capable of carrying a 400 Lb. payload and providing 4000 watts of power to the payload in addition to other power requirements.

Future Candidates for the Airborne Layer

There are a lot of existing or near term candidates in the lower aerodynamic layer. All have different altitudes, speeds and endurances. Some ballpark costs – Predator A is $4-5M. Predator B is ~ $10M. Global Hawk is usually listed at around $10-15M (without the ElectroOptical/InfraRed (EO/IR) package).

JLENS. The Army has a history of interest in tethered platforms – going back to the late 90s and the Joint Land Attack Elevated Netted Sensors (JLENS) program (or aerostat under its former nomenclature). While many in the Army have questioned the applicability of tethered aerostats, there are several smaller aerostats in and around Baghdad today. Several aspects of OIF seem well suited to aerostat operation. In full form, around 6,000 lbs can be lifted to 15kft or so. Power goes up the tether and a fiber optic link is provided to bring data down. In principle, persistence is indefinite – except for brief weather intermissions. The size of the aerostat scales with payload weight and altitude.

Tethered Autogyro. A platform tethered to the ground and held aloft by the high-altitude winds turning the rotor blades, generating both lift and electrical power.
An interesting variant on the tethered platform is provided by the autogyro. Originally called the “Flying Electric Generator” or FEG, it was proposed by an Australian as a commercial power generation platform. A prototype was tested in 1992. Apparently there was a German piloted autogyro tethered to U-Boats and used for ISR around 1942.[25] The power source is made up of wind-driven rotors. In the FEG version, power

would be brought to the ground through a light-weight conductive link. This concept would have a capacity of 1.5Mw based on four 88-ft diameter rotors with a swept area of 2260 m^2. In the aerial support platform version, some or all of the power would be used to operate the payload. As in the aerostat, a fiber optic link could be provided to link data from the ground to the payload.

It should be possible to maneuver the platform through control of the rotors. One concept uses motor-generators so that power could be fed back up the power cable to use if the wind dropped below that required for lift or to support maneuver of the platform to a different location. Based on annual winds in Baghdad – the autogyro could loiter between 25 and 55 kft. The autogyro concept was a joint NASA/USASMDC/ ARSTRAT proposal.

<u>Analysis</u>

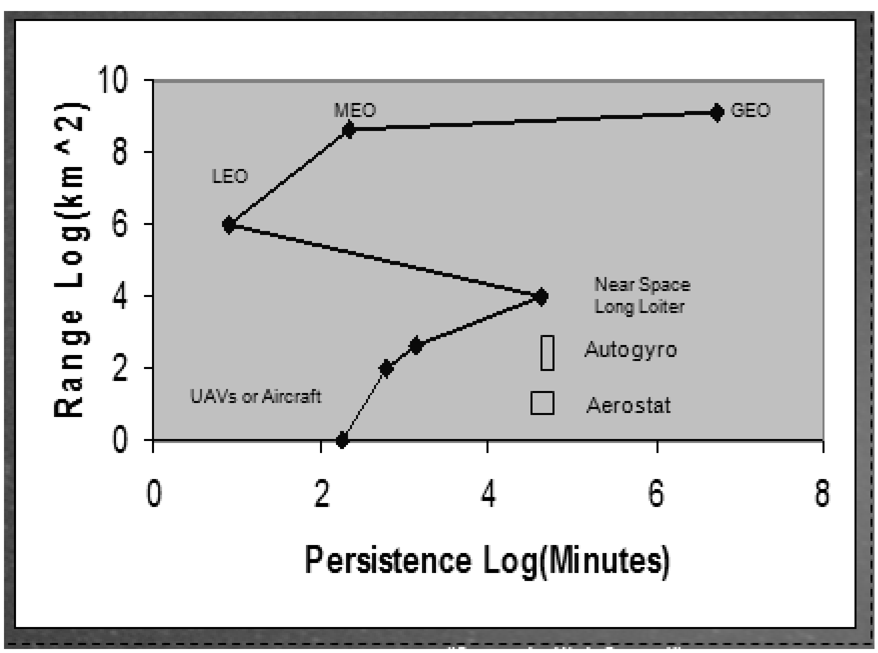

Figure 9: Altitude versus Persistence[26]

Returning to the range versus persistence considerations, the tethered platforms occupy an interesting niche. They compete with the near space platforms for persistence with range and FORs more like the flying platforms. Both will have aerodynamic considerations for the antenna – but at relative airspeeds much less than the flying platforms. Based on compiled research and scientific evidence, there is no easy answer to finding the "best" communications relay platform. In fact there is likely not a best – but rather one that is better employed in any given situation. The choice of a solution set must balance needs across several aspects including the programmatic of developing and / or procuring the required items; the task or set of tasks to be accomplished; the environment / terrain in which operations will be performed; and the nature of the combat. Rapid procurement of low-cost items is usually seen to favor buying an existing, often commercial, capability. Accomplishing an extensive set of tasks in difficult terrain when opposed by a peer is often seen to require the development of a unique capability at a cost affordable only by the Department of Defense. There is also a coupling in many cases between the communications technology and the platform. Obtaining the best balance between performance, mobility and supportability seems point to the vertical component favoring highly elevated platforms that are self deploying and either expendable or self recovering. These technical solutions are often associated with space based assets, high altitude long endurance UAV's or High altitude Airships. However, technical solutions of this nature will only be useful to the degree that they can be guaranteed to be responsive to the tactical commander in all relevant environmental and tactical situations – features that are usually associated with organic assets which deploy and move with the force. The situation becomes more complicated as the emphasis shift s to smaller, possibly dismounted tactical units as is common in complex terrains. The most flexible solution would provide a mix the warfighter can tailor to the tactical situation. The United States need to continue to pursue a multiplicity of options among all three layers, airborne, near space and space that will have the ability to meet communication requirement for the future force.

Conclusion

It should be no surprise that the trend in communications continues to demand more bandwidth and flexibility in bandwidth mode platforms. Future operational concepts are expected to significantly increase the areas where high capacity communications are required. Traditional means of providing high capacity, long range coverage are likely to be inadequate, especially for full motion video, dense data transmission, and multiple voice transmissions across several active theaters simultaneously. There are exciting new opportunities to be considered associated with newer technology – but with corresponding technical, operational and economic challenges. Additional research and development of a variety of options as well as close coordination between the military and industry communities is essential to meet warfighters requirements for the future force.

Endnotes

[1] George W. Casey, “The Army of the 21st Century,” *Army Magazine 2009-10 Green Book*, October 2009, 25.

[2] *Army Tactical Exploitation of National Capabilities (TENCAP)*, http://www.fas.org/spp/military/program/nssrm/categories/atencap.htm (accessed February 19, 2010).

[3] Patrick Rayermann, “Exploiting Commercial SATCOM: A Better Way,” *Parameters* 33, no. 4 (Winter 2003-04): 56.

[4] Ibid., 55.

[5] Barry Rosenberg, “DOD's reliance on commercial satellites hits new zenith,” *Defense Systems* (February 25, 2010), http://defensesystems.com/articles/2010/03/11/cover-story-the-satcom-challenge.aspx (accessed March 29, 2010)

[6] Ibid.

[7] Steve Brozo, US Army Space Missile Defense Command/Army Forces Strategic Command USASMDC/ARTSTRAT (USA SMDC/ARSTRAT) G-6, email message to author, March 16, 2010.

[8] Darrell W. Collier, former Chief Scientist, US Army Space Missile Defense Command/Army Forces Strategic Command (USA SMDC/ARTSTRAT) telephone interview by author, December 2009.

[9] Steve Brozo, US Army Space Missile Defense Command/Army Forces Strategic Command USASMDC/ARTSTRAT (USA SMDC/ARSTRAT) G-6, email message to author, March 16, 2010.

[10] Steve Brozo, US Army Space Missile Defense Command/Army Forces Strategic Command USASMDC/ARTSTRAT (USA SMDC/ARSTRAT) G-6 telephone interview by author, January 10, 2010.

[11] *Joint Network Node (JNN),* http://www.globalsecurity.org/space/systems/jnn.htm *(*accessed February 19,2010) The Joint Network Node (JNN) is an element of the Army’s Joint Network Transport Capability (JNTC), a federation of networks that enables the Army’s transformation to modular, flexible units by providing networking resources at the unit of execution level.

[12] Barry Rosenberg, “Taking different paths to communications-on-the-move,” *Defense System* (May 2009): 27.

[13] Steve Brozo, US Army Space Missile Defense Command/Army Forces Strategic Command USASMDC/ARTSTRAT (USA SMDC/ARSTRAT) G-6, email message to author, January 10, 2010.

[14] AN/TSC-154 SMART-T,”Defense Update”, http://defense-update.com/products/s/smart-t.htm , (accessed February 19, 2010).

[15] *UNIT OF ACTION INTEGRATION*, http://www.arcic.army.mil/ri_uai.htm (accessed January 28, 2010).

[16] Andrew Feickert, *The Army's Future Combat System (FCS): Background and Issues for* Congress, Congressional Research Service, August 3, 2009, 11.

[17] Dennis Brozek, LTC, High Altitude Enabled Capabilities Assessment, Out brief to the Army Space Council, July 9 2009.

[18] Darrell W. Collier, Scientist Emeritus, email message to author, October 19, 2009

[19] It is perhaps humorously interesting that the atomic number for Iridium [from the Latin rainbow)] is 77, but who wants to be called Dysprosium (atomic number 66) [from the Greek term for "hard to get at"].

[20] Darrell W. Collier, Scientist Emeritus, email message to author, October 19, 2009.

[21] Jefferson Morris, "Demise of TSAT is crucial test," *Aviation Week*, May 1, 2009 http://www.aviationweek.com/ aw/generic/story_generic.jsp?channel=space&id= news/TSAT050109.xml&headline=Demise%20Of%20TSAT%20Is%20Crucial%20Test (accessed February 28, 2010).

[22] Steve Brozo, USA SMDC G-6, Telephone interview by author, January 28, 2010.

[23] US Army Space Missile Defense Command/Army Forces Strategic Command Command/ SMDC/ARSTRAT, "High Altitude Efforts", http://www.smdc.army.mil/Factsheets/ha.pdf, (accessed March 12, 2010).

[24] Timothy Clark, "DARPA ISIS Overview Briefing," http://www.darpa.mil/sto/space/pdf/ ISIS.pdf (accessed March 29, 2010).

[25] "The Past, Present and Future of Gyprocopter's, Gyroplanner's and how they fly," *MAGNI GYRO,* Issue Number 12, http://sagpa.co.za/sagpa/images/stories/Archives/MagniNews/ MagniNews200309.pdf (accessed February 19,2010).

[26] Darrell W. Collier, Scientist Emeritus, email message to author, October 19, 2009.